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Application of constant-current coulometry for estimation of plasma total antioxidant capacity and its relationship with transition metal contents

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Abstract

Simple and express coulometric method for the evaluation of the total antioxidant capacity (TAC) of human plasma based on the reaction with electrogenerated bromine is applied. TAC of plasma from patients with different ethiology of chronic renal failure was observed. The levels of antioxidant capacity for venous and arterial plasma are authentically different (15 ± 1 kCl/L versus 11.7 ± 0.7 kCl/L, $p < 0.01$). The application of Vitamin E and ximedon as an antioxidant treatment significantly increase TAC level of plasma. Free liposoluble antioxidants in plasma in α-tocopherol units was determined. Redox potential of plasma is measured and its correlation with lg(TAC) is obtained. Transition metal contents of Fe, Cu, Mn, Ni, and Cr in plasma of patients with chronic renal failure is significantly higher than that for a control group. Correlation analysis has shown negative linear regression between TAC value and transition metals concentration in plasma. This confirms interrelation of processes with participation of free radicals, antioxidants and transition metals as donors of electrons in chain radical processes. Moreover, it shows utility of common parameters, TAC for example, for estimation of efficiency of antioxidant defense system in living organism, in particular its antioxidant status.

Keywords: Total antioxidant capacity; Coulometric titration; Chronic renal failure; Human plasma; Antioxidant therapy; Transition metals; Atomic absorbtion spectroscopy; Redox potential

1. Introduction

Oxygen free radicals are the chemical species formed in all tissues and cells during normal aerobic cellular metabolism that can damage the various intracellular components on which correct cell functioning depends [1].

The free radicals are molecules with an unpaired electron on the outer orbit [2]. They are generally unstable and highly reactive. Examples of reactive oxygen species (ROS) are superoxide anion radical ($O_2^{\bullet -}$), hydroxyl, peroxyl ($RO_2^{\bullet}$), alkoxyl ($RO^{\bullet}$) and hydroperoxyl ($HO_2^{\bullet}$) radicals. Nitric oxide ($NO^{\bullet}$) and nitrogen dioxide ($^{\bullet}NO_2$) are the two nitrogen free radicals. Oxygen and nitrogen free radicals can be converted to other non-radical reactive species, such as hydrogen peroxide, hypochlorous acid (HOCl), hypobromous acid (HOBr) and peroxynitrite ($ONOO^-$). ROS, reactive nitrogen and chlorine species are produced in animals and humans under physiological and pathological conditions [3].

Free radicals can play an important role in the origin of life and biological evolution, implicating their beneficial effects on the living organisms [4]. For example, oxygen radicals exert critical actions such as signal transduction, gene transcription and regulation of soluble guanylate cyclase activity in cells [5,6]. Also, $NO^{\bullet}$ is one of the most widespread signaling molecules that participates in virtually every cellular and organ function in the body. Physiologic levels of $NO^{\bullet}$ produced by endothelial cells are essential for regulating the relaxation and proliferation of vascular smooth muscle cells, leukocyte adhesion, platelet aggregation, angiogenesis, thrombosis, vascular tone, and hemodynamics [7]. In addition, $NO^{\bullet}$ produced by neurons serves as a neurotransmitter, and $NO^{\bullet}$ generated by activated macrophages is an important mediator of the immune response

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